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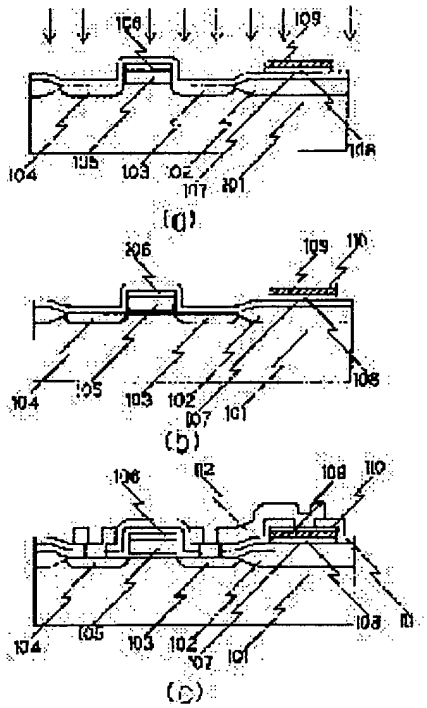
(71)Applicant : **SEIKO EPSON CORP**
(72)Inventor : **KATO KOJI**

(54) METHOD FOR FABRICATING SEMICONDUCTOR DEVICE

(57)Abstract:
PURPOSE: To prevent the variation of or increase in characteristics of elements of a semiconductor device by executing an oxygen treatment of metal oxide dielectric substance forming a dielectric element interposed between two electrodes in an oxygen plasma atmosphere, ozone plasma atmosphere, or an atmosphere containing both in order to lower the temperature of the processing.
CONSTITUTION: Lead titanate and zirconate film 109 that is metal oxide dielectric substance is formed on a MOS semiconductor substrate 101 between two electrodes. Next, this lead titanate and zirconate film 109 is heated for oxyzen processing at 400°C in a gaseous oxygen plasma atmosphere. The use of gaseous ozone plasma in place of the gaseous oxyzen plasma can last an effect equal to or greater than that by gaseous oxyzen plasma. Next, a platinum film is formed as an electrode 110 on the upper layer of a capacitive element using the lead titanate and zirconate film 109 by sputtering. After that, silicon dioxide film is formed as interlayer insulating film 111 by the CVD, and further aluminum film is formed as wiring layer 112 by sputtering.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] this invention mainly relates to the semiconductor memory using the thin film which makes a metallic-oxide dielectric a substrate, especially the structure of a capacity element.
[0002]
[Description of the Prior Art] The proposal of the non-volatile memory of the structure which accumulated as an example the capacity element which consists of a ferroelectric which used the metallic oxide on the silicon substrate like U.S. JP,4149302,B as a semiconductor device using the thin film which makes the conventional metallic-oxide dielectric a substrate, and the structure which has arranged the ferroelectric layer which used the metallic oxide for the gate fraction of MIS type transistor like U.S. JP,3832700,B etc. is made. Moreover, recently, the nonvolatile semiconductor memory of the structure which carried out the laminating to MOS type semiconductor device is proposed by IEDM'87pp.850-851.
[0003] An example of a nonvolatile semiconductor memory of the structure which carried out the laminating of the ferroelectric layer which used the metallic oxide for MOS type semiconductor device is shown in drawing 2 . In drawing 2 , 201 is a P type silicon substrate, LOCOS oxide film for isolation in 202 and 203 are the N type diffusion layers used as the source, and 204 is an N type diffusion layer used as a drain. 205 is a gate electrode and 206 is a layer insulation layer. It is a ferroelectric thin film using the metallic oxide, and 207 is sandwiched by the lower electrode 208 and the up electrode 209, and constitutes the capacity element. 210 is an insulator layer for the 2nd layer, and 211 is a wiring electrode.
[0004] Thus, in order to form the capacity element which carried out the laminating of the ferroelectric thin film 207 using metallic oxides, such as PZT (titanic-acid lead zirconate), on a semiconductor substrate In order to obtain a good ferroelectricity and insulating or high specific inductive capacity, after forming a ferroelectric layer with a spatter or a sol-gel method, heat-treat in the oxygen ambient atmosphere. Or processing in a certain hot oxygen ambient atmosphere is needed like forming a ferroelectric layer by the heating spatter in the inside of the oxygen ambient atmosphere etc.
[0005]
[Problem(s) to be Solved by the Invention] In such an elevated-temperature oxygenation, oxidization of the semiconductor substrate in which the active element was formed is caused. For this reason, when MOS type semiconductor substrate using silicon is used, for example, a move of a silicon-2 silicon-oxide interface and the increase in interface level happen, and change of an element property arises. Moreover, when wiring the semiconductor substrate by the metal metallurgy group silicide, a metallic oxide is produced and the increase in wiring resistance or an open circuit is caused by the elevated-temperature oxygenation.
[0006] Then, this invention solves such a technical probrem and the place made into the purpose aims at preventing the above change of an element property, and the increase in resistance of a metal or a metal silicide by low-temperature-izing the elevated-temperature oxygenation of a metallic-oxide dielectric.
[0007]
[Means for Solving the Problem] It is characterized by this invention including the process which heat-treats the aforementioned dielectric in the manufacture technique of a semiconductor device that the dielectric voxel child to whom the dielectric thin film which uses a metallic oxide as a main component has the structure sandwiched by two electrodes was accumulated on the same substrate in which the active element was formed, in the ambient atmosphere which contains either or both among an oxygen plasma and an ozone plasma.
[0008]
[Example] Drawing 1 (a) - view 1 (c) is a main process cross section in one example of the manufacture technique of the semiconductor device of this invention.
[0009] The manufacture technique of the semiconductor device which carried out the laminating of the capacity element which used the metallic-oxide dielectric on MOS type semiconductor substrate hereafter according to drawing 1 is explained.
[0010] 101 is a semiconductor substrate, for example, uses P type silicon. 102 is a diacid-ized silicon layer for isolation, for example, is formed by the LOCOS method. It is the N type diffusion layer from which 103 becomes the source, and the N type diffusion layer from which 104 becomes a drain, for example, forms with an ion implantation. 105 is a gate electrode, for example, forms contest 3000A polysilicon by the chemical-vapor-deposition method (referred to as CVD below). 106 is a silicide layer for lowering wiring resistance of a gate electrode, for example, forms a 2000A titanium silicide by the spatter. 107 is the 1st layer insulation layer, for example, forms 2000A diacid-ized silicon by CVD. 108 is an electrode (it considers as a lower

electrode hereafter) located in the lower layer of a capacity element which used the metallic-oxide dielectric, for example, forms 2000A platinum by the spatter. 109 is a metallic-oxide dielectric and forms 2000A (referred to as PZT below) of the titanic-acid lead zirconate which is a ferroelectric here by the spatter.

[0011] Next, the oxygenation by the main point of this invention is performed. In this example, 400-degree C heat treatment is performed in an oxygen gas (O2) plasma. What built the heater into the wafer stage of the oxygen plasma generator for photoresist sublation as a processor can be diverted. Here, it is possible to acquire an oxygen plasma, an EQC, or the effect beyond it by using an ozone (O3) plasma as gas (above, drawing 1 (a)).

[0012] Next, 2000A platinum is formed for the electrode 110 (it considers as an up electrode hereafter) located in the upper layer of the capacity element using the metallic-oxide dielectric by the spatter (above, drawing 1 (b)).

[0013] Then, as 2nd layer insulation layer 111, 2000A diacid-ized silicon is formed by CVD, as a wiring layer 112, 5000A aluminum is formed by the spatter and the semiconductor device of one example by this invention is obtained further (above, drawing 1 (c)).

[0014] Now, according to this example, C/cm2 were obtained as a property of a capacity element specific inductive capacity 700, leakage-current 10-7A/cm2, and 12micro of spontaneous polarization. On the other hand, in heat treatment in the usual oxygen gas ambient atmosphere which is a proior art, an almost equivalent value is acquired at the processing temperature of 730 degrees C, and it was inferior also with specific inductive capacity, the leakage current, and the spontaneous polarization at the temperature not more than it.

[0015] Although it was almost equivalent to what a PN-junction reverse current is 8x10-10A/cm2 according to this example, and did not carry out an oxygenation to it, about what was heat-treated in 730-degree C oxygen gas, it was 3x10-8A/cm2. This is for the interface fraction of the silicon substrate 101 and diacid-ized silicon of a PN junction to have oxidized.

[0016] In addition, in this example, as an oxygenation by the main point of this invention, although heat treatment of 400 degrees C and 1 hour was performed in the oxygen plasma ambient atmosphere, as for a controlled atmosphere, ozone (O3) can also acquire it, an EQC, or the effect beyond it instead of oxygen (O2). Moreover, as for processing temperature, it is desirable that it is for 250 degrees C - 550 degrees C.

[0017] In addition, in this example, although the oxygenation made into the main point of this invention was performed before formation of the up electrode 110, it is effective by transparency of the oxygen from the inside of a layer, or an electrode edge also after formation of the up electrode 110, the 2nd layer insulation layer 111 formation, or wiring layer 112 formation.

[0018] In addition, in this example, although PZT was used as a metallic-oxide dielectric, even when tantalum oxide (Ta2O5) was used, the decrement in a leakage current was seen. Moreover, the effect with the same said also of a barium titanate (BaTiO3), a lead titanate (PbTiO3), lead zirconate (PbZrO3), the titanic-acid lead zirconate (PLZT) of lanthanum inclusion, and a strontium titanate (SrTiO3) which has the perovskite type crystal structure in others as a metallic-oxide dielectric was seen.

[0019]

[Effect of the Invention] According to this invention, it has the effect that the semiconductor device of high reliance can be manufactured, by performing the oxygenation of a metallic-oxide dielectric in the plasma ambient atmosphere of oxygen or ozone, and low-temperature-izing processing temperature.

[Translation done.]